Motivation in Mathematics: An Interdisciplinary Approach

An Honors Thesis (HONORS 499)

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Abstract

This research paper describes motivation, types of motivation, how an individual is motivated, and ways an individual can motivate others. Ideas are examined through research summaries and through surveys that were given to both mathematics teachers and students. Finally, there is an exploration of an idea to combine a mathematics class with a physical education class in order to improve student motivation and increase student learning.

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Introduction

Most teachers believe that students will be motivated to learn if they are interested in the subject matter. If the students are not interested in the subject matter, then it becomes a challenge to the teacher to make the subject interesting. When teaching swimming lessons to four year olds, swim instructors relate the pulling action of the arms to scooping ice cream by saying, "Get your scoopers out! What kind of ice cream should we scoop today?"

Mathematics education is similar to teaching swimming. Students need to be interested in what is being taught and must see some practical applications to what they are learning in order be motivated to take an active role in learning. It is a challenge to the teacher to present the mathematics to the students in an interesting way and to show the students how the mathematics is useful. Mathematics teachers have the whole world available to them to make the mathematics interesting and applicable. Mathematics teachers can motivate their students by appropriately integrating other curriculum into their lessons. Physical education is one subject that could be combined with mathematics. The purpose of this paper is to describe the different ways teachers motivate their students and to describe combining mathematics with physical education as a way to motivate students.

Motivation

A common question asked by teachers who teach various grade levels and subjects is, "How can I get my students to pay attention, do homework, behave, and learn or at least try?" (Kolesnik, 1978). Another word that could be substituted for the word "get" in the above question is motivate. How can I motivate my students? It seems that if teachers

could motivate students in all of their classes all day long, they would be able to make awesome strides in education. Teachers are faced with the difficult challenge not only to teach but also to motivate their students at the same time.

Children don't seem to be born unmotivated. Two-year-old children are known to ask "why" all of the time. Infants and young children appear to be naturally motivated by a strong curiosity. Their moves are driven by a desire to explore and discover. They want to make sense of their environment. As James Raffini (1993) puts it, "Rarely does one hear parents complain that their pre-schooler is 'unmotivated.'"

As children grow, however, their passion for learning often seems to shrink. Learning develops into something that is drudgery. More than one in four students leave school before graduating. Though many students are physically present in the classroom, a large number are mentally absent. Many students fail to completely invest themselves in learning (Student Motivation to Learn, 1999).

Concerns over declining test scores and fears that our youth in the United States will not be able to compete successfully in the global market place of the twenty-first century have brought on educational reform. The educational reform has brought on more rigorous national achievement standards. The reform movement holds both teachers and students accountable for these national achievement standards. To reach these high standards, the school year has been extended, more homework has been assigned and more tests have been administered to students. The policy used to reach the standards is referred to as the policy of intensification (Covington, 1996).

Raising standards is important to improve achievement, but more than simply raising standards is needed to facilitate in student learning. If students are not succeeding now,

will simply adding new courses and raising academic standards prove to be the only solution? Criticism of raising standards was put bluntly by a businessman who recently commented,

> If I had a situation in which one third of my products [students] fell off the assembly line along the way [national dropout rate prior to high school graduation] and two thirds of those remaining did not work right in the end, the last thing I would do is speed up the conveyor belt!

The solution lies elsewhere, requiring us to shift our thinking to motivation (Covington, 1996).

Motivation answers the age-old question, "why" of human behavior. Why does Jordan volunteer and thirsts for more? Why does Beth do exactly what she is told to do and nothing more? And why does Cory sit through the same class as Jordan and Beth, seeming to be a million miles away from the subject matter? Three qualities depend on one's motives or reasons for learning. These three qualities are preference, energy level, and persistence. Answering the questions which explain why a student chooses to work on particular tasks, works longer on one task than another task and why some give up before others do requires one to look into motivation (Covington, 1996).

To help research the ideas for this thesis paper, the author gave a survey to 100 high school mathematics students and eight mathematics teachers. The students and teachers were from a high school located in mid-America. Copies of the student survey and the teacher survey can be found on pages 27 and 28 of this paper. Some typical responses to the first question on what motivates the student in school were parents, teachers, friends, grades, going to college, and getting a good job to make money. Other responses included group work, moving, prizes, hands on activities, pride, sports, basketball, "It's

easier to do stuff if you know stuff," scholarships, interesting subjects and fun learning. Other, possibly unusual responses, were the weather, girls, "nothing, but the end of the day," "to get good grades so my parents will buy me things," "the thought that if I finish this day, I'll have one less day 'till school's out" and lunch.

Some students wrote about how they motivated themselves. One student wrote, "I pretty much motivate myself in school. I push myself to get good grades. I really want to achieve. My mom encourages me to get good grades, and I really want her to be proud also." Another student wrote, "to be the best that I can be. To learn because that is why we are here..."

Psychologists and general consensus suggest that motivation is an internal state or condition and is sometimes described as a need, desire, or want. Motivation serves to activate or energize behavior. Motivation is an influence of needs and desires on the intensity and direction of behavior (Kleinginna and Kleinginna, 1981). Franken (1994) gives more additional parts to the definition of motivation. He says motivation is an arousal, direction, and persistence of behavior. A person or student who is motivated needs to be energized, directed, and persistent. Students are energized by needs, directed by pursuing goals that give rewards that fulfill the needs, and persist in behaviors that give the rewards that fulfill the needs (Reward and Punishment Systems, 1996).

Educators agree that when students are highly motivated to learn, they will almost always learn. Further, when students are motivated, classroom management does not prove to be as large of a problem. Teachers are told to keep their students engaged in something interesting, challenging and rewarding. This is easier said than done (Kolesnik, 1978).

Teachers want their students to be motivated to learn, but how to do this is complicated. Motivation is not easily understood nor is there one easy answer to explain and describe motivation. Perhaps one thing educators agree upon regarding motivation is that it is not a process that is learned and mastered. Motivation, itself, cannot be placed in a bag of tricks that is handed down from teacher to teacher. No motivation formulas exist that are guaranteed to work for all students and all subjects. What may work for one particular student may not necessarily work for another student (Covington, 1996).

Covington (1996) used the term, "motivational equity," to refer to how students are unequal in many ways. Each student enters school at different starting points. Students have different talents and learning styles. Every student, though, can share common reasons for learning. With motivational equity, students feel the excitement of intellectual discovery practice problem solving, and can experience the joy of self-improvement.

Students differ physically, socially, emotionally and intellectually. They have different ages, grade levels, attitudes, interests, values, goals, home environments, races, potential, social cultures, socio-economic status and religious backgrounds. Students also come to class with different experiences and certainly with different abilities to learn. In addition, they also differ in what they want to learn and what they think they need to learn. Taking into consideration all these differences, students are likely to differ in the motivational stimuli they need to succeed and excel (Kolesnik, 1978).

Ruggiero (1998) suggests that the degree to which someone is motivated depends on: 1) the strength of the motives or needs inside an individual; 2) the expectation of what outcomes certain actions will produce, and 3) how much an individual wants a certain

payoff over all the other wants and risks that are faced. Needs, expectations and incentives make up a person's motivation and determines what a person does and how far he or she gets in life.

Logan and Wagner (1965) suggest that some students work for immediate payoffs, while others learn when they see they can prevail over others in class, and still others are drawn by those assignments that require creativity and self-expression. Reasons why students learn largely determine how much they learn, how well they retain knowledge, and furthermore, whether the knowledge they gain enhances their willingness to learn more.

According to Covington (1996), the problem schools are facing is not necessarily the lack of student motivation. Students are motivated, perhaps even over-motivated, but too many students are motivated for the wrong reasons. Students may be motivated to avoid failure by not participating at all. Others are motivated to defy a system they believe irrelevant in their lives. Students need more positive reasons for learning, and teachers need to recognize that some students are motivated for the wrong reasons.

The second and third questions in the student survey given to the high school students by the author of this paper required responses that reflected the students' opinions of mathematics. Out of 100 students surveyed, 76 gave negative responses to questions about mathematics. Some reasons why particular students disliked mathematics were: there is one way to do something, doing problems, not being good at it, math is too confusing and technical, math has no purpose, and no real life applications of what you learn. One student wrote "I don't (like mathematics) because I talked to older people and they said they never had to use much advanced math, only the basics." Other students

wrote, "it makes my brain hurt," "it's a thorn in my side that I just can't get rid of" and "it is a natural talent and if you don't have it you have to work twice as hard." All in all, if a student wrote that he or she disliked math, the reason was because that person did not see a need for what was being leaned in the real world or because he or she was not successful in mathematics.

Those students who indicated that they liked mathematics wrote in the survey that they did so because they like to work with numbers, figure out tough problems, find math challenging and interesting, use math in their everyday lives, feel good when they understand, it and it's easy. In response to the question about whether or not a student likes mathematics, some students wrote that they liked mathematics because, "I do well in it," "I like to solve puzzles," or "I need it for my job." All in all, if a student wrote that he or she liked math, it was because the individual was able to see how what was being learned could be used in the real world or because he or she was successful in mathematics.

Types of Motivation

Motivation is said to originate in two different ways. Extrinsic motivation arises from a source outside the individual. An example of extrinsic motivation in education is the awarding of grades in education. Someone else wants an individual to earn a grade, and the grade is a reward. Students work and learn to receive a grade. The grade is the motivator (Kolesnik, 1978). Extrinsic types of motivation provide clear expectations, give corrective feedback, provide valuable rewards, and make rewards available (Huitt, 1998).

Intrinsic motivation, on the other hand, arises from within the individual. Individuals do something because they want to do it. External elements are unnecessary. An example of intrinsic motivation is someone who reads simply because he or she loves to read. Intrinsic motivation is related to the concept of interest development of a student's interests (and classroom strategies for making schoolwork interesting), creativity, curiosity, and attention (Kolesnik, 1978). Intrinsic motivation shows why learning a particular concept or skill is important, creates curiosity, provides a variety of activities, provides games and simulations, sets goals for learning, relates learning to student needs, and helps students develop a plan of action (Huitt, 1998).

Lepper (1988) suggests that there are many advantages to intrinsic motivation as opposed to extrinsic motivation. When students are motivated intrinsically, they tend to use strategies that call for more effort and that enable them to use more critical thinking. Students who are motivated intrinsically tend to prefer tasks that are moderately challenging, whereas extrinsically motivated students move towards tasks that are low in degree of difficulty. Extrinsically motivated students are more likely to put forth the minimal amount of effort necessary to get the maximal reward.

Huitt (1998) suggests that teachers try to develop their students' sense of intrinsic motivation as much as possible. However, since all students are different, teachers need to realize that not all students will be appropriately motivated intrinsically. Extrinsic motivation will work, but teachers must remember that this type of motivation will last only as long as the student is under the control of the teacher. When outside of, or beyond the class, and unless the desired goals and behaviors have been made into intrinsic motivation, the learner will stop the desired behavior.

Covington (1996) suggests that achievement needs are the desires to succeed and to excel. Achievement motivation keeps individuals productive and gives them self-respect. Achievement needs are made up of several factors including wanting approval from experts, to make money, to succeed on our own, respect form friends, to compete and win, to work hard and to excel.

How to Motivate

The concept of motivation in education is based on the teacher's ability to inspire, challenge, and encourage students to take an active role in their learning. Maslow argues that everyone seeks to satisfy two basic levels of needs. The different needs are lower level needs which include physiological needs, security needs, and the need for love and belonging, and the higher level needs include self esteem and achieving one's full potential. Once any of these needs is met, it becomes less of a motivator (Johnson, 1999).

Charles Backes (1994) listed fifteen suggestions for increasing the motivational level of students in The Technology Teacher. The suggestions were:

1. Involve the students in hands-on activities.
2. Make the lesson applicable to the students' aspirations.
3. Involve the students in developing class activities.
4. Assist the students in setting reasonable goals.
5. Make learning enjoyable.
6. Encourage student participation in related student organization.
7. Help students feel good about themselves.
8. Grab the students' attention from the beginning.
9. Involve yourself in activities with the students.
10. Be sincere with your praise.
11. Keep students too busy to get bored.
12. Plan activities that will ensure student success.
13. Be prepared for each class.
14. Make your expectations clear.
15. Smile!!

These fifteen suggestions are not all of the methods available and used to increase the motivational level of students. Backes' suggestions are general and only touch the surface of increasing student motivation. For instance, Number 5, which suggests that the teacher make learning enjoyable, is broad. How can a teacher make learning enjoyable? Teachers can make learning enjoyable by having the students learn in groups or by linking what the teacher is teaching to the students' interests.

Ways to Motivate

There are definitely more in-depth ways to increase the motivational level of students than the fifteen suggestions Backes made. Teachers use bribes, goal setting, rewards, punishment, interdisciplinary education, games, projects, cooperative work, etc., to motivate their students. Each of these methods of motivating has worked for different teachers and helps students enjoy learning and want to learn more.

One of a teacher's goals should be to develop his or her students' intrinsic motivation. One way to effectively do this is by establishing a positive "psychological environment," says Maehr (1991). Teachers can create this type of environment by establishing policies and programs that:

- stress goal setting and self-regulation/management
- offer students choices in instructional settings
- reward students for attaining "personal best" goals
- foster teamwork through group learning and problem-solving experiences
- replace social comparisons of achievement with self-assessment and evaluation techniques
- teach time management skills and offer self-paced instruction when possible

Motivational Methods

Teachers use various forms of motivation depending on the teacher and on the students. Some of the methods of motivation overlap with other methods, and some methods are used to motivate and for reasons beside motivation. The methods have advantages and disadvantage. Some of the methods of motivating are described in the next several sections.

Classroom Climate

The majority of learning takes place in the classroom. Students are most likely to acquire a strong motivation to gain knowledge in the classroom. Teachers make the classroom a place that motivates students to learn. Teachers may cover their walls with motivational sayings to help inspire the students. One teacher wrote in the teacher's survey (given by the author of this thesis paper) that she motivates her students by smiling, while another teacher wrote that she motivates her students by talking with them and showing them that she is approachable. If students see the classroom as a caring, supportive place where there is a sense of belonging and all of the students are valued and respected, the students will be more likely to participate more in the process of learning (Student Motivation To Learn, 1999).

The teacher plays a significant role in controlling the motivational level of his or her students. In the student survey given to the high school mathematics students by the author of this paper, in response to the question regarding what motivates them, one student wrote,

> "The teacher! If I have a teacher I like, I want to do good and get a good grade in that class because I kind of feel like I owe it to that teacher, but if I have a teacher I dislike, I just don't care and don't get as good a grade."

Rewards

Rewards act to motivate students by giving them what they want or need. Some examples of rewards in education are shortened homework assignments, longer recesses, candy, special privileges (e.g., line leader, coming to the board), class parties and extra credit.

Holidays are a common time when teachers use rewards to motivate. Just before Halloween Day, a mathematics teacher made stations (called "houses") around the room. Each house had a worksheet that dealt with the current algebra chapter the students were studying at the time. After successful completion of a worksheet, each student was rewarded with a piece of candy. Then, the student was to go on to the next house to try to earn another piece of candy.

One teacher who was surveyed for this paper by the author used stickers or stamps to mark success or improvement on her students' papers. She wrote on the survey that she used these rewards to motivate her mathematics students, but that the rewards do not work for every student. Many teachers use extra credit as a way to motivate their students. Though extra credit or bonus points may work for some students, one teacher referred to giving out bonus points on the teacher survey given by the author of this paper as a way of motivating that she has found not to work. She wrote, "The good student who doesn't need the points does the work. The poor student never bothers or does it in lieu of daily work and loses out."

Though rewards have worked for many teachers, and many teachers use rewards as motivation, the effects are not going to be long lasting in general because the type of motivation is extrinsic or comes from an outside source, the teacher. Students will not

always have someone monitoring them giving them candy or shortened assignments when they do a job well. Referring to the Halloween activity described above, the students in the algebra class were motivated to do the worksheets that day before Halloween, but was their intrinsic motivation aroused? Will they expect a reward similar to this in the future, and will they not work hard in the future because there is not an immediate reward of a piece of candy?

School is not exactly the real world. Teachers are preparing students for the real world. Though motivating a student intrinsically is the goal of education, it is not always realistic. In response to the question in the teacher survey given by the author of this paper regarding what way of motivating students do not work, one teacher wrote, "Giving them (the students) freedom to perform (does not work). Students even in high school are rarely self-motivated. They need structure and direction."

Teachers need to use extrinsic motivation as a step to developing their students intrinsically. Using motivational rewards like candy is a step for students and does not have to be just like a job in the future. The algebra teacher, who did the Halloween Activity in her class, motivated her students by using candy. In return, the students learned important mathematical concepts that they will use in their lives.

Some other disadvantages of giving rewards to motivate students are that teachers often times fail to use the intrinsic reward of goal accomplishment. Teachers may also fail to manage reward systems effectively. Rewards are given out on an inconsistent occasion or are uneven. The reward system of bribing, for example by using candy as a reward for accomplishing a specific task, can also become rather costly for a teacher too. Is there a better way to motivate students?

Reinforcement and Punishment

Teachers use reinforcement and punishment to motivate students. A reinforcement is a consequence that is pleasant. A punishment is a consequence that is unpleasant. Any event that increases the likelihood of a behavior is a reinforcement, and any event that decreases the likelihood of a behavior is a punishment (Punishing and Reinforcing Behaviors, 1999). Any event that is presented is called positive, and any event that is removed is called negative. An example of positive reinforcement is giving a dog a bone for sitting. The reward is desired and the behavior, sitting, is strengthened. This type of reinforcement is thought to interfere with problem solving and can go against task involvement and intrinsic motivation (Positive Reinforcement, 1999). An example of negative reinforcement is removing a needle from a finger. An example of positive punishment is picking up a crying baby. An example of a negative punishment is telling a student that he or she will have no recess until he or she behaves.

Games

Many mathematics teachers use games and puzzles to motivate their students. A mathematics teacher can find lists of games and puzzles related to mathematics on the Internet. These games may include logic problems, comics, discussions, pictures, brain teasers, offbeat puzzles, and magic tricks. All of these games are related to mathematics. A teacher can use one of these games to stimulate interest in a topic. The mathematics games test skill and patience. Students can feel great satisfaction once they have conquered a game or puzzle and will gain confidence for future mathematics questions.

An example of a mathematics magic trick was used by the author of this paper when she was introducing writing an equation for a set of numbers in an algebra class. The

teacher used the magic trick to open a lesson. The teacher listed the numbers one through ten on the chalkboard and drew a short line after each number. She then asked one student to write one whole number on the first line. She had her back to the board. She asked another student to put up a second number on the second line. Another student found the sum of the number at number one and the number at number two and put it on the third line. The students completed the list by adding the two previous numbers to obtain the next number. At the end, the teacher had her students sum all of the numbers in the list. She had the number written down before the students were even done with the list. The students were amazed to see that the teacher could come up with the sum without having seen the first two numbers. The students made conjectures as to how they thought the teacher was able to do this trick. As it turned out, the teacher showed algebraically how she was able to find the number in her head after having seen only the seventh number. Not only was the algebra teacher able to determine the sum of the numbers in the list, but she was able to get the attention of just about every student in her class. Her students were able to see excitement in mathematics.

Competition

Competition is also used with games in education. Teachers have reported great success from competition in the classroom through games. Jean Panning, an elementary teacher who was interviewed by the author, pointed out that there must be a balance while using competition in the classroom. The teacher said that overuse of games and competition is unhealthy because class competition can make a few students feel great and many students feel bad about their performance at the same time.

Some teachers use the concept of competition to motivate their students. Teachers may do this by posting the range and average of a recently taken test. Students are able to compare their scores with their peers and are set to compete. This type of education develops the students' extrinsic motivation. They are motivated by an outside source, their peers. Ideally the students should be led to compete with themselves and try to improve their own score.

Mindjogs

Donna Walker Tileston (1999), a speaker on block schedules, has been going from school to school instructing teachers on how to use the block schedule efficiently. One of her suggestions is that teachers open every day with what she calls a "mindjog." Tileston wrote that mindjogs are based on brain research about how the brain learns. A mindjog is a problem of the day. It is written on the board or on the overhead projector before the bell rings, and students know to work on it when they come into the classroom for about five minutes each day. These mindjogs are challenging yet reachable for most students. The teacher may choose to have the students work in groups, take a few days, etc., depending on the particular question.

Mindjogs for a mathematics class may be found in mathematics textbooks and on the Internet. Teachers who have used mindjogs have found that the students look forward to solving the mindjog. The purpose of the mindjog is to get the students into a routine and ready for learning and also to motivate the students by sparking interest and building interest.

In the teacher survey given by the author of this paper, a teacher named problems of the week, a form of a mindjog, as the one way she motivates her mathematics students on

the teacher's survey. She wrote, "Problems of the week which are not standard problems (motivate students). They force students to look at a problem in a different way. Students who are not super math students often come up with unique solutions."

Goals and Success

Goal setting is a powerful technique that can give strong returns in all areas of life. Simply stated, the process of setting goals allows one to choose where he or she wants to go in life. By knowing what one wants to achieve, one knows what he or she has to concentrate on and improve. Setting goals helps one to recognize and overcome obstacles. Goal setting gives someone long-term visions and short-term motivation (Goal Setting, 1998).

By setting goals, students achieve more, improve their performance, improve their motivation to achieve, increase their pride and satisfaction in their performance and improve their self-confidence. Setting goals helps students taste success, and success motivates students to achieve more. By setting goals, and measuring achievement, individuals are able to see what they have done and what they are capable of doing (Goal Setting, 1999)

A teacher wrote on the teacher survey given by the author that "nothing motivates like success." He wrote that he tries to make sure that all students are successful. The process of reaching goals and seeing achievement gives one the confidence one needs to be able to achieve higher and more difficult goals.

Defining tasks in terms of specific, short-term goals can assist students to associate effort with success. Verbally expressing the purposes of specific tasks when introducing them to students is also beneficial and aids in motivating because students can see where

they are being directed (Stipek, 1988). Teachers can write the lesson's objective on the board and have the students copy the objective in their notes. Some mathematics textbooks have the lesson objectives written at the beginning of every lesson (Glencoe, 1998).

During school students are introduced to the need to become motivated. Teachers begin to motivate students extrinsically with the goal to produce students who will start to motivate themselves intrinsically. By demonstrating to students why getting their work done in a timely manner is vital, teachers will allow students to see the importance of self-motivation in their lives (Johnson, 1999).

Projects

Teachers give projects as assignments in order to make sense of all the mathematics their students are learning. Projects help students see that what they are learning can be used and is worthwhile. Often times, projects tie together the material that the students are covering and allows the students to see the practical uses of it.

A project was assigned to each student in a high school discrete mathematics class. The students were to get into groups of four and design a city. The students were able to pick the location of the city and the time in which the city existed for the project. The students had to make paths for the mail deliverer, trash workers, street cleaners, etc. To finalize the project, the students had to present their city to the class.

Group Work

Davidson (1990) suggests that traditionally, mathematics has been viewed as an isolated, individualistic subject, a subject that requires students to sit alone with paper, a

pencil, and a calculator struggling to understand assigned exercises. This type of mathematics leaves students feeling lonely and afraid.

Cooperative learning helps students in mathematics. Small group cooperative learning addresses the problem of traditional mathematics instruction in many ways. Small groups provide social support, offer opportunities for success, allow for different approaches to be discovered, promote mathematics discussion, and provide a means by which students can think creatively (Davidson 1990).

The role of small groups in mathematics is addressed in the *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (1989):

> Small groups provide a forum for asking questions, discussing ideas, making mistakes, learning to listen to others' ideas, offering constructive criticism, and summarizing discoveries in writing.

Student Responsibility

Involving students in classroom planning is a contemporary motivational technique. Teachers can involve students in collaboratively making a set of classroom rules for students and the teacher on the first day of school. The teacher can ask what they expect of him or her, and in turn, the teacher can talk about what he or she expects of the students. Together, the students and the teacher can devise a list of procedures they agree to follow.

Another way to involve the students in planning is to have them describe a "Quality Product" before projects. The students help supply criteria, objectives, the worth, and how to grade particular projects (Goal Setting, 1999). Teachers may have their students determine their own weights in a weighted grading system within certain

specifications. Giving students the responsibility of deciding their own specific weights may very well push them into following through with the class and taking responsibility for their own learning.

One middle school teacher wrote on the teacher survey given by the author that he had his accelerated middle school mathematics students design their own, individual rubrics for a project. Though grading the project was time consuming with 28 different grading scales, he reported that the students were motivated by having the responsibility of designing their rubric.

Hands-on Activities

Students learn in different ways. Some may be able to look at the book and learn from reading, while others need to be led through examples that they can see. Some students are kinesthetic learners and learn best when they are moving around and are able to feel learning through hands-on activities. Modeling mathematics activities engages students with manipulatives and mathematical models. Both college-bound and tech-prep students can find meaningful hands-on activities that relate to life and work. Mathematics teachers can stimulate the kinesthetic learner by using, for example, yarn to make triangles in the classroom when covering the Triangle Inequality Theorem in a geometry class. Students can serve as vertices and other students can pick out lengths that would make a triangle.

Technology

The use of technology is growing in popularity in the mathematics classroom. By using technology, students are able to visualize many mathematical concepts.

Technology allows students to see concepts quickly and see complicated concepts that would not have been covered without the aid of technology.

Interdisciplinary Education and Problem Solving

Pythagoras said that the world could be understood through numbers and mathematical principles. He also discovered a hidden order in the world through mathematics. Hope Martin (1996) feels that integrating mathematics across the curriculum is a way to breathe life into mathematics. Martin included the following quote in his book, which describes what Pappas observed:

> Mathematical things – numbers, statistics, fractals, cyberspace, dimensions, polyhedra, tessellations – have a pervasive way of creeping into our everyday experiences until the objects seem to become household terms. How does this happen? Through comments made by newscasters, statespeople, artists, writers, philosophers, scientists, musicians, architects, people in all areas of life. Why? Because mathematical things help to measure, describe, predict, and quantify so many facets of our lives. Be it things that deal with our bodily functions, our economics, our environment, politics – almost anything you can name will some way have mathematics connected to it. Name ten things you use or do in a day and see how many of these have something mathematical linked to them.
>
> - Theoni Pappas
> *The Music of Reason*

Interdisciplinary education connects subjects like mathematics with other topics like biology, geography, art, history, and health. A teacher may motivate a lesson by using a lesson opener that by poses a real-world application or makes an interdisciplinary connection.

One subject that uses mathematics is science. In the last few decades, mathematics and science have become important keys to opportunity. A good knowledge

of mathematics is important in many fields. It is the "language of science, the key to business and finance, and an essential element in understanding the technology of change," (Martin, 1996).

The National Council of Teachers of Mathematics has defined mathematical connections as one of its four primary standards. Curriculum should be designed so that students are given the opportunity to see relationships among different topics in mathematics, use mathematics in their everyday lives, and apply mathematical thinking and problem solving to other curriculum areas (Martin, 1996). Some school systems have moved to an integrated mathematics curriculum. The integrated mathematics curriculum uses problem solving and practical applications to learn mathematics. The courses are not called algebra or geometry.

Most countries that out-perform the United States in pre-college mathematics education use an integrated curriculum (Contemporary Mathematics in Context, 1998). Traditional topics of algebra, geometry, trigonometry, and functions remain important parts of the secondary school mathematics curriculum. However, there has been a demand to shift emphasis from a curriculum dominated by memorization of isolated facts to one that emphasizes conceptual understanding and mathematical problem solving (Lovell, 1999).

Many scientific studies have shown that traditional methods of teaching mathematics are not only ineffective, but also stunt the growth of students' mathematical reasoning and problem-solving skill. Traditionally, students gain mathematical skills by imitating demonstrations by the teacher and the textbook (Lovell, 1999). This type of traditional learning is referred to as "Parrot Math" by Thomas O'Brien (1999).

Integrating Mathematics and Physical Education

A way to use many of the motivational methods described in this paper to motivate mathematics students is to combine mathematics with physical education. The class would take up two hours of the school day that are back to back. Students would get credit in physical education and mathematics. The class would also be optional. Students might choose to take the regular route of separate mathematics and physical education.

A class that combines mathematics and physical education could motivate students by allowing them to see applications of the mathematics they are learning, learn kinesthetically, compete, have success, make goals, use technology, work in groups, and more. The class might also give confidence to the student who is afraid of mathematics, but loves physical education.

To have a successful mathematics/physical education class, a teacher should have a well-planned curriculum. Mathematics teachers know that most of what they teach has practical value, but they have little or no experience in other fields of study that would enable them to use relevant applications. For example, when studying percentages, a teacher may pose the question, "Pedro counted 30 cars that passed his house. Twelve of those cars were black cars. What was the percentage of black cars that passed Pedro's house?" This type of question is ridiculous because, though it is a word problem, the students will more than likely never actually count cars that pass their house. Students will be motivated to learn the mathematics presented in examples if they can actually see themselves using the mathematical skills someday in the future (Saunders, 1988).

There are many resources available for assistance when designing a curriculum that combines mathematics and physical education. Football Math is a book for teachers that includes 30 "touchdown activities" that combine math and physical education (1995). Olympic Math includes 30 "gold medal" activities about all sorts of sports (1996). Sports Shorts is a problem solving handbook for teachers that actually has the student do a physical activity and mathematics (1987).

Summary and Conclusions

Teachers are going to have many students who need to be led towards being intrinsically motivated. This paper has described many of the different ways a teacher can motivate his or her students, as well as the different ways that might work for different students. The author of the paper also suggests that one way to motivate students in mathematics is by having a class that combines mathematics and physical education.

In conclusion, being faced with the challenge of motivating students, if acted upon, motivates the teacher. Finding new material, creating new connections between mathematics and physical education, and seeing success is motivating for the teacher as well as the students.

Dear Student,

I am in the process of writing a thesis paper on motivation in mathematics education. I would greatly appreciate it if you would take a few minutes to complete this survey. Your responses will be used as data for my paper.

Thank you,
Miss Panning

1. List what motivates you in school.

2. Do you like mathematics? Why or why not?

3. What color would describe mathematics? Why?

4. What motivates you in mathematics?

5. How could you be more motivated?

6. How do you see mathematics being used in any of your other school subjects?

Dear Teacher,

I am in the process of writing a thesis paper on motivation in mathematics education. I would greatly appreciate it if you would take a few minutes to complete this survey. Your responses will be used as data for my paper.

Thank you,
Shelly Panning

1. What motivates you in mathematics?

2. Name one way you motivate your students.

3. Name one way of motivating students that you have found not to work? Why?

4. If you were to team teach with another teacher in another discipline, which subject area would you choose to combine with mathematics? Why?

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